GUIDELINES FOR IRRIGATION SYSTEMS MAINTENANCE

2012

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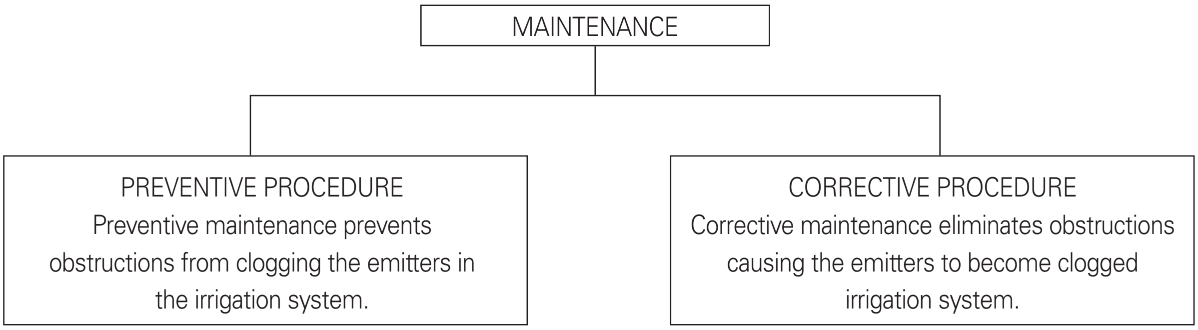
CONTENT

INTRODUCTION

The implementation of a simple yet strict maintenance program for drip irrigation systems will achieve the following:

- Keep the system operating at peak performance
- Increase the system's work life expectancy.

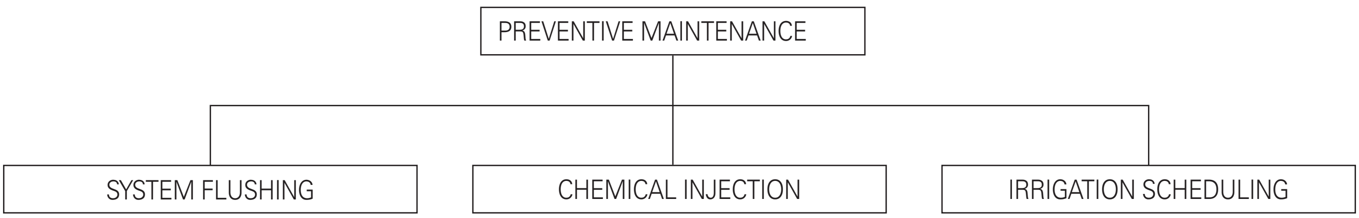
This manual will guide you in determining the correct procedure and its implementation. The best way to determine if your maintenance program is effective is to constantly monitor and record the flow rate and pressures in the system.
Maintenance is divided in two categories: PREVENTIVE and CORRECTIVE.



PREVENTING CLOGGING IN THE SYSTEM

Preventive maintenance can be divided in three categories:

1. Flushing the system
2. Chemical injection
3. Irrigation scheduling



SYSTEM FLUSHING

Flushing the irrigation system reduces to a minimum the accumulation of pollutants, pushing them out of the system.
Flushing the system entails opening the flushing valves in the main line, the sub-main lines or laterals while under pressure. This procedure increases the water flow velocity in the pipes and laterals to clean the internal walls and/or dripper filters of pollutants, flushing them out of the system.

- The system must be flushed at regular intervals. The frequency depends mainly on the water quality and the maintenance-flushing program.
- Flushing is more effective when the flow rate within the main, sub-main or dripperlines is increased, flushing contaminants from the internal walls. In some cases, the downstream pressure must be increased in order to enable these flow rates in the main, sub-main or dripperlines. The pressure should not exceed the value indicated in the following table, according to the dripperline's wall thickness.

Dripperline description	Pipe diameter (mm)	Wall thickness (mm)	Wall thickness (mil)	Max. working pressure (bar)	Max. flushing pressure (bar)
12060	12	0.15	6.0	1.4	1.6
12080	12	0.20	8.0	1.7	2.0
12125	12	0.31	12.5	2.5	2.9
12150	12	0.38	15.0	3.0	3.5
12200	12	0.50	20.0	3.0	3.5
12250	12	0.63	25.0	3.5	4.6
16060	16	0.15	6.0	0.8	0.9
16080	16	0.20	8.0	1.0	1.2
16100	16	0.25	10.0	1.2	1.4
16125	16	0.31	12.5	1.8	2.1
16150	16	0.38	15.0	2.2	2.5
16200	16	0.50	20.0	2.5	3.3
16250	16	0.63	25.0	2.8	3.6
22080	22	0.20	8.0	0.8	0.9
22100	22	0.25	10.0	1.0	1.2
22135	22	0.34	13.5	1.5	1.7
22150	22	0.38	15.0	1.8	2.1
22250	22	0.63	25.0	2.5	2.9
25135	25	0.34	13.5	1.2	1.4
25150	25	0.38	15.0	1.4	1.6
35135	35	0.34	13.5	0.9	1.0
35150	35	0.38	15.0	1.0	1.2
12010	12	1.00	39.0	3.5	4.6
16009	16	0.90	35.0	3.0	3.9
16010	16	1.00	39.0	3.5	4.6
16012	16	1.20	47.0	4.0	5.2
17012	17	1.20	47.0	4.0	5.2

20010	20	1.00	39.0	3.5	4.6
20012	20	1.20	47.0	4.0	5.2
23009	23	0.90	35.0	3.0	3.5
23010	23	1.00	39.0	3.0	3.5

*Maximum allowed flushing pressure is half an hour consecutively, provided at least 5 dripperlines are kept open in their final positions

NOTE: Flushing may be manual or automatic, by opening the end of the main, sub-main or the dripperline.
If the system does not have a drain collecting pipe, it is recommended not to open more than 5 dripperlines at one time.

Flushing is recommended at least once a month.
Netafim™ offers collector valves and tubes to facilitate flushing.

Flushing Velocities

Location	Recommended rate (m/sec.)
Main line	1.5
Sub-main line	1.5
Dripperline	0.5

FLUSHING TIME CALCULATION FOR MAIN AND SUB-MAIN LINES

$$\frac{\text{Length of the pipe (meters)}}{\text{Flow rate (m/sec)*60}} = \text{Flushing time (minutes)}$$

VERIFICATION OF THE FLOW RATE IN THE DRIPPERLINE DURING THE FLUSHING

Place the open dripperlines close to the neck of a 1.5 liters bottle, verify that all the water enters the bottle, measure the time (in seconds) it takes to fill the bottle, and use the following table in order to ascertain that the speed is at least 0.5 meters per second

Internal diameter (mm) of the dripperline	Quantity of water (liters) per half meter of dripperline	The bottle must be filled in less than...(seconds)
11.8	0.054	28
14.2	0.079	19
16.2	0.103	15
17.5	0.120	13
20.8	0.169	9
22.2	0.193	8
25.0	0.245	6
35.0	0.481	3

NOTE: Flushing the main, sub-main and dripperlines will reduce the accumulation of organic and mineral material in the system considerably, minimizing therefore the quantity of chemical products required. This will save time and money

In the dripperline flushing process there are two waves of contaminants.

- The first wave is the removal of contaminants that collected at the end of the dripperline.
- The second wave is the result of the flushing effect. The color of the water is not as dark as the first time, but takes more time.

The dripperline must remain open for at least 1.0 minute, until the water is clean after the second wave.

IRRIGATION SCHEDULING

Adequate irrigation scheduling may prevent or minimize possible clogging caused by:

1. ROOT INTRUSION

The intrusion of roots may occur when the plant suffers from “water stress” and the roots are searching for moisture.

Gradually, the roots may grow into the dripper, blocking the water passage in the dripper.

By monitoring the soil moisture and scheduling irrigation accordingly, it is possible to minimize water stress, thus minimizing conditions where roots grow inside the dripper in search of water.

If a crop requires “dry periods” during and/or at the end of its irrigation season, it is possible to implement two alternative programs:

a. A series of short irrigation cycles (technical) to maintain a higher content of humidity in the soil, around the dripper, without interfering with the agronomic decision of “dry periods".
b. The injection of specific herbicides that “burn” only the root tips without damaging the plant.

2. CONTAMINATION FROM EXTERNAL PARTICLES

When the soil becomes oversaturated and the subsurface dripperlines are empty, water could flow in the opposite direction, from the soil to the dripper hole, bringing soil particles with it. Under these circumstances, the dripperlines act as small draining tubes. The small particles of soil that are carried towards the dripperline may, if they are allowed to dry, eventually clog the drippers. Introducing a short irrigation cycle soon after the rain ends, will help flush the small particles from the piping and prevent clogging. When there is a very intense and long rainy period, it is recommended to flush the system prior to the beginning of the next irrigation season.

If these conditions are foreseen, Netafim™ recommends using Anti-siphon (AS) drippers.

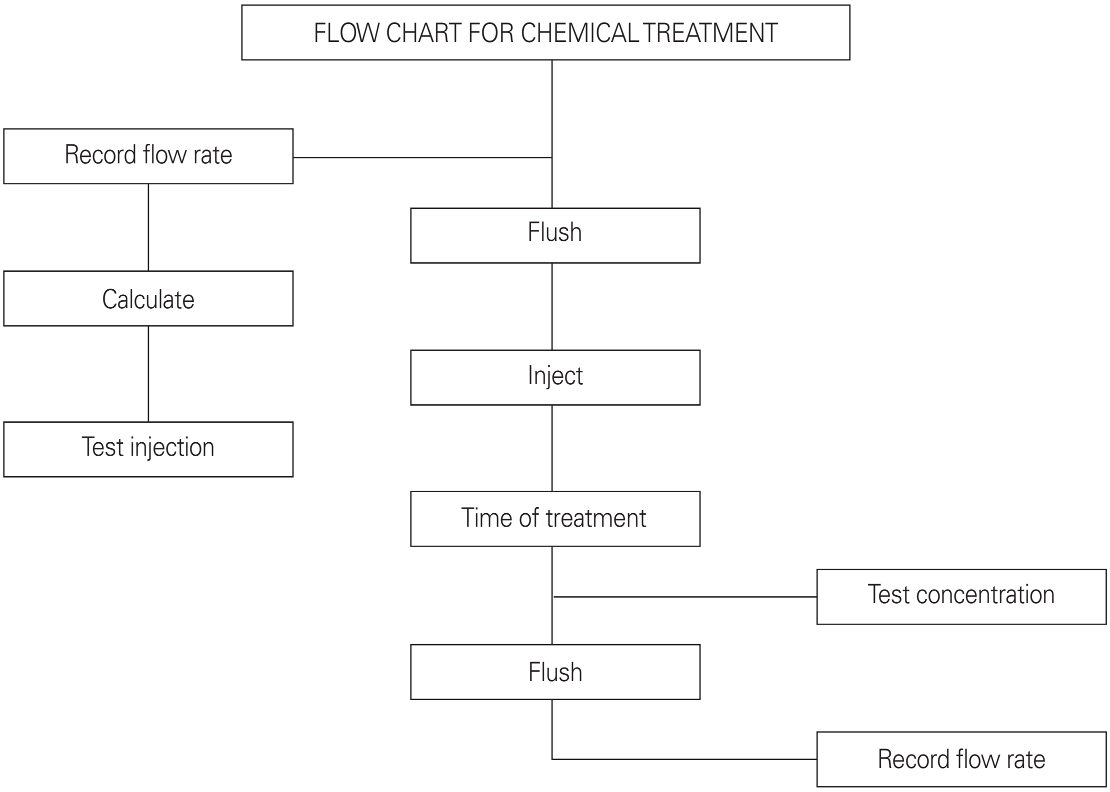
In drip irrigation systems with emitters without Anti-siphon, activating the system for a period of 10 minutes (after pressurizing) is recommended, in order to flush out the accumulated dirt particles.

CHEMICAL INJECTION

The injection of different treatments may prevent, eliminate, dissolve or solve occurrences of clogging.

The following flow chart is a guide for determining the order in which to perform chemical injection:

1. Begin by recording the system's flow rate at operating level.
2. Calculate the dose to be injected, based on the recommendations included in this guide.
3. Perform a test injection, in order to verify and/or rectify the correct functioning and the respective flow rate of the injection system.
4. Flush the system according to the instructions in the section "Flushing the System" in this guide.
5. Inject the chemical according to the calculations (point 2) above, depending on the specific treatment.
6. Flush the system, taking into account the advancement times (See Advancement time in page 21).



REMOVAL OF CHEMICAL RESIDUES FROM THE SYSTEM

Upon completing the injection of products (fertilizers, disinfectants, oxidants, herbicides, etc.), it is recommended to continue irrigating only with water for as long as necessary to remove all residue of these products from the system.

SYSTEM DESCRIPTION FORM

Netafim™ recommends completing the following data in order to learn the system's properties and be able to receive advice (if necessary).

Name ____________________

Country ____________________

Definition of the Problem

❑ Clogging ❑ Routine Test

❑ Other: _________________________

General Information

Type of irrigation (dripper, micro-sprinkler, other): ______________________

Type of emitter (PC, UniRam™, MegaNet™, etc.): ____________________

Age of the equipment __________________________

Size of the system _________________________ ha

System flow rate __________________________ m^3/h

Total length (m) of dripperline per hectare __________ m

Location of the dripper lines ❑ Surface ❑ subsurface Depth: ______ m

Emitter flow rate _____________ l/h

Average length of dripperline ________ m

Operating pressure:

After the head control filter ________ bar

At the end of the dripper line with the lowest pressure ________ bar

Irrigation frequency (specify units, for example hours/day, days/week, pulses) _________

Soil composition:

% of sand ________

% silt ________

% clay ________

Crop: ____________________

Water source: ❑ Well ❑ River ❑ Lake

❑ Dam ❑ Reservoir ❑ Canal

❑ Other ________________

Reservoir size: ______________________

Holding time: ___________________

Water maximum depth: ________________

Pump Data

Type of pump (horizontal, vertical, etc.): ____________________________

"Floating Suction Point"

Pumping depth (in relation to the surface of the water): ___________________

"Permanent Suction Point"

Location of the suction point (Distance between the surface and the bottom): __________

Direction of Suction

⬆ Vertical upwards ➨ Horizontal ➨ Vertical downwards

Pipe Data

Distance between the water inlet and the pumping point: ___________________

Length of pipe from the pump to the field: ____________________

Pipe diameter: _______

Type of pipe: ❑ Steel ❑ PVC

❑ Cement Asbestos ❑ Other ______________

Filter Data

Working pressure at the head control filter outlet: _________bar

Main filters ❑ Gravel ❑ Disc ❑ Screen ❑ Hydrocyclone

Control or sub-main filters ❑ Screen ❑ Disc

Other types of filter ❑ Specify type _______________________________________

Filtration level (microns): _________________________

Filters flushing frequency

❑ Filtration system works properly

❑ Automatic filter works properly but the control filters clog quickly

❑ Automatic filter clogs quickly and is back-flushed frequently

Data on Injecting Fertilizers and Chemical Products

Specify the type of fertilizer / chemical product injected into the system: ____________________

Concentration of fertilizer / chemical product injected into the system: ______________________

Dose of fertilizer / chemical product injected into the system (l/m3/h): _______________________

Specify the formula used for injection: ____

Specify any additional chemical product injected into the dripping systems: __________________

Water Treatments

❑ Chlorination ❑ Acid Treatment ❑ Other: ______________________

Information about emitters

Specify the number of clogged emitters

❑ Many ❑ Some ❑ Few ❑ None ❑ %: ______

Indicate the location of the obstructed emitters:

❑ The last lateral

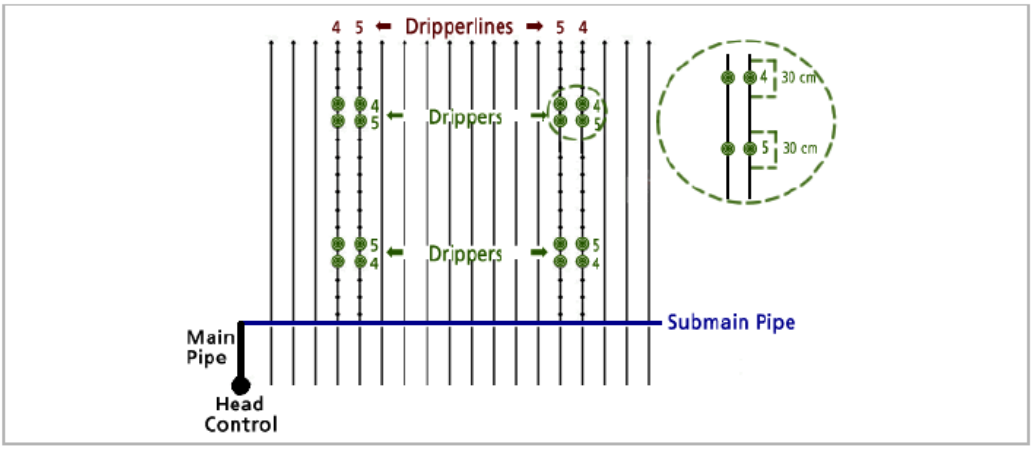
❑ The last emitters

❑ Uniform dispersion in the plot

SAMPLING EMITTERS

In order to verify the performance of the emitters, we recommend the following sampling protocol:
When the area is composed of several plots, take the sample from one representative plot.
Take samples of a section at least 20 cm long from the lateral with the dripper in the center, as shown in the following figure:

NOTE: These instructions are suitable both for integral drippers and for online drippers and/or the micro-sprinklers. When taking samples of online drippers, they should be sent together with a lateral sample of at least 20 cm, as described below.



Taking samples from the dripperlines

TO TAKE A SAMPLE FROM DRIPPERLINES, PERFORM THE FOLLOWING STEPS:

1. Cut a 20 cm emitter sample from the 4th and 5th drippers at the beginning and the end of the dripperline.
2. The dripperlines to be sampled are those located in the 4th and 5th places at the beginning and the end of the plot.
3. Each sample must comprise: the emitter and at least 10 cm of the tube on either side of the dripper.
4. Wrap the 16 samples firmly with wet paper and put them in a plastic bag.
5. Send the samples to Netafim™ for analysis.
6. Repair the dripperlines in the field.

If a different sampling protocol has been used, it is highly important to describe the process used, and attach this description to the samples.

TAKING WATER SAMPLES

To analyze the water to be used in the irrigation system and determine its quality

The water quality refers to the concentration of chemical substances dissolved and suspended in the water, as well as the physical and biological properties of the water.

The water quality for agriculture is defined according to the following criteria:

- Agronomic water quality – to what extent is it compatible with the type of soil or the crop.
- Water quality for irrigation – to what extent does it prevent clogging of the irrigation system.

The source of water may be: potable water, waste water, residual water, wells, reservoirs, canals or drainage water. All of them require variable levels of treatment before being used.

It is not possible to collect all the parameters related to evaluating the water quality in specific water sources, since the water comes from different places, with a high probability that water from additional sources has been incorporated along the way.

The user has no control over the water quality, which varies also with time. This means that different treatments are required at different times in order to ensure that water quality is suitable for the irrigation system.

Therefore, in order to monitor the water quality, Netafim™ recommends taking samples and analyzing them.

Other factors affecting the water quality, and must be taken into account, are the fertilizers and chemical products used in the same system for various treatments.

1. Before taking any sample, flush a clean one liter bottle, using water from the source to be sampled.
2. Fill the bottle so that no air at all remains inside the bottle (if possible, squeeze the bottle to expel any remaining air).
3. Close the cap firmly and store the sample in a clean place in the shade.
4. Send the sample to Netafim™ (or other laboratory) as soon as possible after taking the sample.
5. Write the following data on the sample bottle:
   a. Customer's name
   b. Location
   c. Water source
   d. Date sample was taken
6. When the sample is sent to an external laboratory, request an analysis of the following parameters:

- Electrical Conductivity (EC)
- pH
- Calcium (Ca)
- Magnesium (Mg)
- Sodium (Na)
- Potassium (K)
- Bicarbonate (HCO_3)
- Carbonate (CO_3)
- Chlorine (Cl)
- Sulfate (SO_4)
- Phosphate (PO_4)
- Nitrogen-Ammonium ($N\text{-}NH_4$)
- Nitrogen-Nitrate ($N\text{-}NH_3$)
- Boron (B)
- Iron (Fe)

- Manganese (Mn)
- TSS
- TSD
- Silicon (Si)
- BOD (When waste, effluent industrial and/or recycled waters are used)
- COD (When waste, effluent industrial and/or recycled waters are used)

The above parameters are essential for a correct analysis.

In some cases, additional parameters will be needed in order to complete the correct interpretation of the water quality, for example: turbidity, dissolved Oxygen, Redox, etc.

If in doubt, consult with the Netafim™ laboratory regarding water quality.

7. Before taking a sample from the end of a dripperline, we must wait until the pressure has stabilized. Then, open the end of the line and wait 2-3 minutes before taking the sample. When the sample is taken from the head control end, Netafim™ recommends taking the sample after the system has been working for at least for one hour.

NOTE: Take the samples after the pump, but as close to it as possible.

If the field to be irrigated is located more than 1 km away from the pump, take another sample of water at the beginning of the plot.

In new irrigation projects, it is recommended taking samples of the water close to the future suction point.

PRECAUTIONS FOR PREVENTING SAND PENETRATION INTO IRRIGATION SYSTEMS

NOTE: Sand is one of the most harmful elements for the drippers. Sand does not decompose. After penetrating any type of dripper, it cannot be removed or dissolved, even using chemical products

Sand can penetrate the system in two ways: with the water flow or directly from the local sandy soil.

NOTE: When water is pumped from a reservoir, river or canal (not from a well), the water must be preferably pumped from a floating point at 0.5 to 1.0 meters depth below the water's surface.

Filtering the water supply will keep sand out of the system.

NOTE: Hydrocylone filters are adequate for separating the sand from the water.

Nevertheless, the biggest threat is the sand coming from the local sandy soil, which might enter the system directly through the dripperlines during their installation or repair. The best way to prevent damage caused by the penetration of sand is taking suitable preventive actions.

IN ORDER TO PREVENT THE PENETRATION OF SAND DURING INSTALLATION OR REPAIR, IMPLEMENT THE FOLLOWING STEPS

Check that the system's filtration system is complete and functioning properly, to ascertain that sand will not penetrate.

1. Check that the system's filtration system is complete and functioning properly, to ascertain that sand will not penetrate.
2. After installing the pipes, attach end connectors immediately.
3. After completing the installation, flush the system using the maximum allowed pressure. Start by flushing the main pipes and continue with the sub-main pipes.
4. Verify that both the main and the sub-main pipes are clean.
5. Do not leave any pipe inlets or outlets open, even for short periods of time.
6. Install start connectors and connect the laterals immediately after making the holes.
7. Flush the dripperlines, 5 dripperlines at a time or with the help of the collecting pipe.

NOTE: Never leave pipes with open holes in the soil.

Any product to be injected into the system must pass through a filter to ensure that all sand particles and/or other impurities are separated out.

In irrigation systems using well water, the presence and concentration of sand particles must be verified and a Hydrocyclone filter should be installed if necessary.

INJECTING SUBSTANCES INTO THE IRRIGATION SYSTEM

DETERMINING THE CHEMICAL SUBSTANCES FOR INJECTION

There is a large variety of chemical fertilizers and disinfectants, in solid, liquid and gaseous states worldwide.
Due to the different chemical techniques used in their preparation, combined with the various concentrations and dosages of minerals, emulsions and coagulants, it is impossible to provide a pre-approved list of permitted or prohibited products and manufacturers.

NOTE: Before injecting any chemical product into your system, determine its degree of compatibility. The injection of incorrect chemical substances may be damaging to the system.
When incorrect products are injected, the following problems may be expected:
Sedimentation in the drippers due to the reaction between the water and the chemical products
Physical and/or chemical damage to the emitters

Following is a list of permitted chemical products. When contemplating the use of any other chemical product or combination of products, Netafim™ recommends:

1. Consult the Agronomic Department of Netafim™.
2. Send the new chemical product/s to Netafim™ for a complete test.

PERMITTED CHEMICAL PRODUCTS
FERTILIZERS

NOTE: Before using any chemical product, it is essential to obtain information from its manufacturer with respect to its chemical quality, purity, recommended dosage, solubility, EC-pH as well as method and order of preparation.

NOTE: Remove the membrane or oily surface layer formed after the preparation of any product.

NOTE: Any product not included in this list requires prior approval from Netafim™.

The following chemical products (liquid or highly soluble) are permitted for injection in drip irrigation systems:

N - Nitrogen

- Urea
- Ammonium Nitrate
- Nitric Acid
- Ammonium Sulfate
- MAP – Mono Ammonium Phosphate

P - Phosphor

- Phosphoric Acid
- MAP – Mono Ammonium Phosphate
- MKP - Mono Potassium Phosphate

K - Potassium

- Potassium Nitrate
- Potassium Chloride
- Potassium Sulphate
- Mono Potassium Phosphate

Micro-elements

- Chelates, EDTA, DTPA, EDDHA, HEDTA, ADDHMA, EDDCHA, EDDHSA, Boric Acid

DESINFECTANTES DE SUELO

NOTE: Netafim™ authorizes the use of certain chemical agents. Products that are not authorized in this summary must pass a control test in Netafim's laboratory, prior to being utilized, to ascertain if safe for use with our systems.

FUNGICIDES, HERBICIDES, DISINFECTANTS

Products authorized by Netafim™:

- Metham Sodium
- Telone II
- Formaldehyde

There are other options; contact the agronomic department of Netafim™ for additional details.

Read the product instructions very carefully.
It is necessary to continue irrigation for at least 30 minutes with water free of chemical products, verifying the flushing time with the tables showing the Advancement times (page 21).
In irrigation systems with anti-drainage drippers (CNL), in addition to the previous point, it is necessary to open the ends of the dripperlines for flushing.

Possible problems

In general, products, both those approved and not approved by Netafim™, contain approximately the same percentage of active material. The differences between the various products are:

- The quality of the product
- The storage time
- The country of production
- The dosage
- The quality of the emulsion

With good quality emulsion the active components mix with the water without creating layers of different compositions. When these conditions are not fulfilled, the active ingredients could cause damage to various parts of the system, such as valves, drippers, flow meters, etc., when they come into contact with highly active concentrations of the injected product. These products are very corrosive to some metals and also react with various polymers (depending on the product).

FORBIDDEN CHEMICAL SUBSTANCES

The use of certain chemical products in drip irrigation systems is forbidden.

- Never use any Poly-phosphates
- Never use Red Potassium Chloride
- Never use Borax
- Never use organic products with a high content of suspended solids (without preliminary treatment)
- Never use products or fertilizers with low solubility, e.g. Gypsum
- Never use oily chemical products, oily solvents, petroleum products or detergents
- Never use mineral fertilizers together with organic fertilizers

ADVANCEMENT TIMES IN DRIPPERLINES

TO ENSURE THE OPTIMUM DISTRIBUTION OF INJECTED PRODUCTS (FERTILIZERS, HERBICIDES, OXIDANTS, ETC.)

The irrigation system is used also as a method for distributing products through the water.

These products, such as fertilizers, insecticides, fungicides, nematicides, herbicides, etc., must be totally soluble in the water and will be injected into the system at some point, penetrating into the soil through the system. When there is any doubt if certain products should be injected through the irrigation system, consult a specialist at Netafim™.

When these products are injected into the water, they will move and advance through the system almost at the same rate as the water.

The time it takes for a product injected into the pressurized system to arrive at a given point can be calculated and must be taken into account, in order to allow the injected product to reach its final destination.

This calculated Time is called Advancement Time.

The Advancement time may be divided into three phases.

1. Time I: is the calculated time that passes between the injection point and the valve in the field. In the case of several valves, the most distant valve must be taken into account.

2. Time II: is the calculated time that passes between the valve and the last dripperline in the sub-main pipe.

3. Time III: is the time that passes between the moment when the product enters the drippe line and reaches the last emitter (dripper, micro-sprinkler or sprinkler).

The total relevant Advancement Time will be calculated according to the location of the injection point. The Advancement Time is the same time for clean water, calculated without the product, after ending its injection, to get to any specific point in the system. To remove all residue of the injected product from the system, it is necessary to observe the Advancement Time of the water (without products) in order to clear the system.

The Advancement Time is a calculated time, and will be minimally influenced by the physical and chemical properties of the product. For practical purposes, it may be assumed that the product advances in the system at the same rate as water.

The Advancement Time is calculated when the system is pressurized and stable.

The Advancement Time should not be confused with the system filling time.

The filling time is the time required for an empty system starting to fill, until it reaches a stable, pressurized state, and is quite different from the Advancement Time.

It is recommended to request the Advancement Time for each operation of the irrigation system, according to its hydraulic design.

Advancement time in dripperlines (minutes) – Time III

Dripperlines of 16 mm – 14.2 mm ID

Distance between drippers (m)	0.3				0.5				0.8				1.0			
Nominal flow rate of the dripper (l/h)	0.8	1.1	1.6	2.7	0.8	1.1	1.6	2.7	0.8	1.1	1.6	2.7	0.8	1.1	1.6	2.7
Total length of the lateral (m)																
100	29	21	14	8	36	26	18	11	51	37	25	15	64	47	32	19
200	32	23	16	9	40	29	20	12	57	41	29	17	73	53	36	22
300	33	24	17	10	43	31	21	13	61	44	30	18	77	56	39	23

Dripperlines of 17 mm – 14.6 mm ID

Distance between drippers (m)	0.3				0.5				0.8				1.0			
Nominal flow rate of the dripper (l/h)	1.0	1.6	2.3	3.5	1.0	1.6	2.3	3.5	1.0	1.6	2.3	3.5	1.0	1.6	2.3	3.5
Total length of the lateral (m)																
100	16	12	8	5	30	18	13	8	43	27	19	12	52	33	23	15
200	18	13	9	6	33	21	14	9	49	31	21	14	59	37	26	17
300	19	14	10	6	35	22	15	10	52	33	23	15	63	39	27	18

Dripperlines of 20 mm – 17.5 mm ID

Distance between drippers (m)	0.3				0.5				0.8				1.0			
Nominal flow rate of the dripper (l/h)	1.0	1.6	2.3	3.5	1.0	1.6	2.3	3.5	1.0	1.6	2.3	3.5	1.0	1.6	2.3	3.5
Total length of the lateral (m)																
100	28	17	12	8	42	26	18	12	62	39	27	18	75	47	33	21
200	31	19	13	9	47	30	21	14	70	44	31	20	85	53	37	24
300	32	20	14	9	50	31	22	14	75	47	33	21	91	57	39	26
400	34	21	15	10	52	33	23	15	78	49	34	22	95	59	41	27
500	35	22	15	10	54	34	23	15	81	51	35	23	98	61	43	28

Dripperlines of 23 mm – 20.8 mm ID

Distance between drippers (m)	0.3				0.5				0.8				1.0			
Nominal flow rate of the dripper (l/h)	1.0	1.6	2.3	3.5	1.0	1.6	2.3	3.5	1.0	1.6	2.3	3.5	1.0	1.6	2.3	3.5
Total length of the lateral (m)																
100	39	24	17	11	60	37	26	17	88	55	38	25	106	66	46	30
200	43	27	19	12	67	42	29	19	99	62	43	28	120	75	52	34
300	46	29	20	13	71	44	31	20	106	66	46	30	128	80	56	37
400	47	30	21	14	74	46	32	21	111	69	48	32	134	84	58	38
500	49	30	21	14	76	48	33	22	114	71	50	33	138	86	60	39

Dripperlines of 22 mm – 22.2 mm ID

Distance between drippers (m)	0.3				0.5				0.8				1.0			
Nominal flow rate of the dripper (l/h)	0.8	1.1	1.6	2.7	0.8	1.1	1.6	2.7	0.8	1.1	1.6	2.7	0.8	1.1	1.6	2.7
Total length of the lateral (m)																
100	56	40	28	16	71	51	35	21	99	72	50	29	126	91	63	37
200	62	45	31	18	79	57	39	23	111	81	56	33	142	103	71	42
300	65	47	33	19	83	61	42	25	118	86	59	35	151	110	75	45
400	67	49	34	20	87	63	43	26	123	89	62	36	157	115	79	47
500	69	50	35	21	89	65	45	26	127	92	63	38	163	118	81	48

Dripperlines of 25 mm – 25.0 mm ID

Distance between drippers (m)	0.3				0.5				0.8				1.0			
Nominal flow rate of the dripper (l/h)	0.8	1.1	1.6	2.7	0.8	1.1	1.6	2.7	0.8	1.1	1.6	2.7	0.8	1.1	1.6	2.7
Total length of the lateral (m)																
100	70	51	35	21	90	65	45	27	126	91	63	37	159	116	80	47
200	78	57	39	23	100	73	50	30	141	102	70	42	180	131	90	53
300	82	60	41	24	106	77	53	31	150	109	75	44	191	139	96	57
400	86	62	43	25	110	80	55	33	156	113	78	46	200	145	100	59
500	88	64	44	26	113	82	57	34	161	117	80	48	206	150	103	61

GUIDELINES FOR ACID TREATMENT IN IRRIGATION SYSTEMS

Acids may be used for dissolving, preventing and/or decomposing salts, carbonates, phosphates, hydroxides, etc.

NOTE: Acid treatment is ineffective on most organic substances.

SAFETY

WARNING

ACIDS ARE TOXIC AND DANGEROUS TO HUMANS.

BEFORE USING ACID, READ ALL THE MANUFACTURER'S INSTRUCTIONS FOR ACID TREATMENT AND ALL LOCAL LEGAL PROVISIONS REGARDING ITS USE.

- Always add acid to water – NEVER add water to an acid.
- Avoid contact with the eyes. Any contact of acid with the eyes may cause blindness.
- Avoid contact with the skin. The contact of acid with the skin may cause burns.
- Use protective clothing when working with acid: goggles, gloves, a mask, long pants, a long-sleeved shirt, and closed high shoes.
- Avoid swallowing and inhaling. Swallowing of acid or inhaling its fumes could be fatal.
- During acid treatment, a second operator must be present who could, if necessary, provide first aid.
- Remain on site throughout the acid treatment. Keep all unauthorized personnel away from the treatment area.

INJECTING ACID INTO THE SYSTEM

IN ORDER TO APPLY AN ACID TREATMENT TO THE SYSTEM, THE FOLLOWING STEPS MUST BE TAKEN:

1. Verify that the injection pump is of high capacity and acid resistant.

NOTE: Acids are very corrosive on materials such as steel, aluminum, asbest-cement, etc. PE and PVC tubing are resistant to acids. Consider these factors before planning the treatment. In case of doubt, always consult Netafim™.

2. Before beginning the treatment, flush all the components of the system thoroughly using maximum flow.

NOTE: Flushing the system before using acid is essential, to prevent damage to the system.

3. Inject the acid into the irrigation system for the time required to attain the desired concentration during the stipulated treatment time.
4. Turn off the injection pump.
5. Continue irrigation during the time required according to the Advancement Time table, page 21.
6. Flush the injection pump with clean water after every use.

ACID CONCENTRATIONS

The concentration of acid added to the irrigation water depends on the type of acid being used, its percentage and valence.

NOTE: Acids must be free of insoluble impurities, such as gypsum, oils, etc.

Recommended Acid Concentrations

Percentage of Acid	Recommended Concentration in Treated Water
Hydrochloric Acid 33%	0.6%
Phosphoric Acid 85%	0.6%
Nitric Acid 60%	0.6%
Sulfuric Acid 65%	0.6%

If the acid used has a percentage different from the data included in this table, adjust the concentration according to the percentage relative to the concentrations recommended above.

CALCULATE THE ACID CONCENTRATION WHEN A DIFFERENT INITIAL CONCENTRATION IS USED:

EXAMPLE:

Sulphuric Acid 98% is available. What percentage must be used?

Y x 98% = 0.6% x 65%

Y = (0.6% x 65%) / 98% = 0.4%

RECOMMENDATIONS FOR THE ACID INJECTION PROCESS

Prevent incrustations of salt in water with a high potential for formation salt with low solubility

1. The pH of the water must be reduced continuously or at a predetermined frequency

2. The required pH level will be determined according to the water quality

It is recommended to titrate the irrigation water with the acid to be used, in order to calculate the required pH.

DETERMINING THE TITRATION CURVE OR TABLE

Required equipment

- Bucket
- pH digital meter, or litmus paper
- 1 liter of the same irrigation water to be used
- Acid

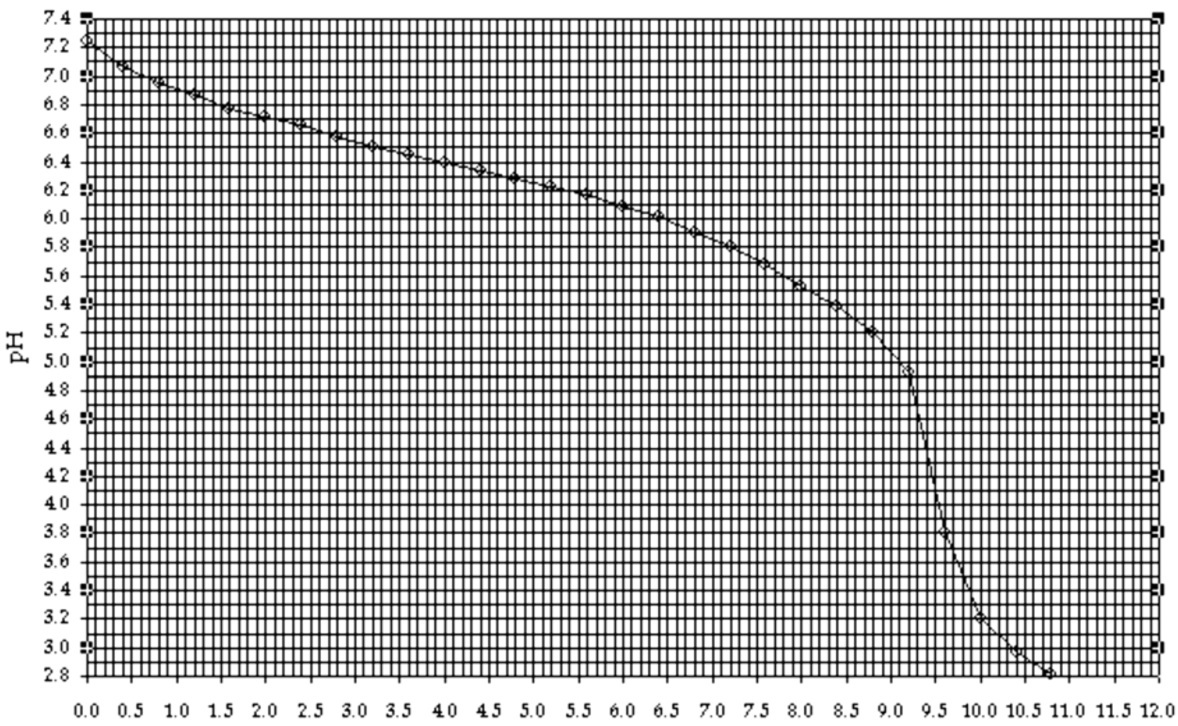
Procedure

1. Put 1 liter of irrigation water in the bucket.
2. Record the pH level of the water.
3. Add 1cc of the acid and mix the solution.
4. Record the pH level of the solution.
5. Repeat steps 3 and 4 until reaching the desired pH level.

NOTE: If the pH level changes abruptly, it is recommended to dilute the acid with water or use a higher volume of water.

6. Construct the curve or table using the variation from the initial pH in coordination with the volume of acid as parameters.
7. The result will provide an approximation of the amount (in cc or ml) of acid per liter of water needed to reduce the pH to the required level.
8. 1cc or ml of acid per liter of water = 1 liter of acid per m^3 of water

Example, titration curve (illustrative):



(cc or ml) per liter of irrigation water

Dissolving the incrustations of salts of low solubility in irrigation systems

Recommended concentration of acids is 0.6% (see table in the previous paragraph)

In order to attain this 0.6% concentration of acid in the water, inject 1.0 liter of acid for every 1.0 m^3/h (cubic meter per hour) to be treated for 10 minutes.

NOTE: In order to verify that the treatment is efficient, the pH at the furthest point should be less than 3 for at least 3 minutes.

EXAMPLE:

Flow rate of the equipment: 50 m^3/h

Necessary acid: 50 liters

Injection time: 10 minutes

$$\text{Required acid concentration} = \frac{50 \text{ liters}}{(50\ m^3/h \times 1000\ l/m^3 \times 1h/60\ min) \times 10\ min} = 0.6\%$$

NOTE: If the injection pump capacity is lower than required, and it will not be capable of injecting all the required acid within the specified time, another injection pump must be added.

If the capacity of the injection pump is larger than necessary, add water to the tank with the solution until reaching to the volume necessary for ensuring 10 minutes of solution injection.

GUIDELINES FOR CHLORINE INJECTION INTO DRIP IRRIGATION SYSTEMS

Chlorine is a strong oxidant. It is very useful for the following purposes:

1. Prevent and eliminate the growth of organic slime, ferrous slime and sulfurous slime.
2. Oxidize elements such as Iron, Sulfur, Manganese, etc.
3. Clean organic sedimentation and bacterial slime from irrigation systems.
4. Improve filtration efficiency, especially for gravel or sand filters.

NOTE: Chlorine is effective only on organic matter.
Chlorine is ineffective against inorganic materials, such as sand, silt, minerals, scale, etc.

SAFETY

WARNING

CHLORINE (LIQUID, SOLID OR GASEOUS) IS TOXIC AND DANGEROUS TO HUMANS.
BEFORE USING CHLORINE, READ ALL THE INSTRUCTIONS FOR TREATMENT WITH CHLORINE AND FOLLOW ALL THE LOCAL LEGAL REGULATIONS AND THE MANUFACTURER'S INSTRUCTIONS.

- Before filling any tank with chlorine solution, it must be flushed thoroughly to remove any remaining fertilizer or other chemical product.
- Avoid contact with the eyes. If Chlorine comes in contact with the eyes, it could cause blindness.
- Avoid contact with the skin. If Chlorine comes in contact with the skin. It could cause burns.
- Use protective clothing when working with chlorine: goggles, gloves, mask, long pants, long-sleeved shirts, and high closed shoes.
- Avoid swallowing and inhaling. Swallowing chlorine or inhaling its vapors could be fatal.
- During treatment, a second operator must be present who could, if necessary, provide first aid.
- Stay in the location during the full duration of the treatment. Keep all unauthorized personnel away from the treatment area.

NOTE: Direct contact between chlorine and fertilizers might cause an explosive thermal reaction. This is extremely dangerous!

NOTE: The injection of chlorine into irrigation water containing fertilizers is not recommended.

NOTE: When using anti-drain irrigation systems (CNL) the maximum recommended chlorine concentrations may change and it is necessary to consult with Netafim™ before applying it.

MATERIALS

Chlorine is available for commercial use in gaseous, liquid or solid state. Each type has its advantages and disadvantages. The suitability, availability and price of each material must be taken into account before deciding which to use.

Commonly available forms usually include:

- Gaseous Chlorine (Cl2, 100% active chlorine).
- Solid Chlorine (Calcium Hypochlorite, contains 60-85% active chlorine).
- If the water contains high alkaline levels, hardness and/or high pH, it is recommended not to use this form.
- Liquid Chlorine (Sodium Hypochlorite, contains 7-13% active chlorine). Liquid chlorine is unstable, and decomposes quickly in the storage tank, depending on time, temperature and solar radiation.

NOTE: Do not store liquid chlorine for long periods of time. Recommendations: Keep in the shade, and paint the storage tank with white paint if it must be kept under direct solar light.

Application Methods

Use one of the two following chlorination methods:

1. Continuous Injection

Chlorine is continuously injected during the entire irrigation cycle. This is the most efficient method, but chlorine consumption is highest.

2. Selective Injection

Chlorine is injected during the last irrigation hour. Do not forget to take into consideration the time it takes for chlorine to get to the end of the system (see Advancement Time, page 21). With this method, both chlorine consumption and efficiency are lower than with continuous chlorination.

The frequency of this selective treatment will be determined according to the water quality in the system, and could be daily, weekly, monthly, etc.

DETERMINING THE INJECTION POINT

Chlorine can be injected at two different points of the system. Each position has its advantages and disadvantages.

Injection point

Injection Point Location	Comments
As close as possible to the main pump of the water source (river, dam, well)	Prevents the growth of bacterial slime in the main pipe and protects the irrigation system better than when the point is far from the water source.
Far from the main pump and as close as possible to the treated field	Does not protect the main pipe and it is not recommended if effluent, sulfur, iron and/or manganese are present

DOSAGE

NOTE: It is dangerous to inject chlorine and acid into the same injection point at the same time. When it is necessary to reduce the pH using acid injection, chlorine and acid must be injected at two different points, with at least 3 meters between the two points.

The acid injection point will be before the chlorine injection point.

It is forbidden, during chlorine injection, to reduce the pH level of the water to below 6.

The required quantity of chlorine depends on the water quality, the cleanliness of the pipes and laterals, and also on the size of the system.

MEASURING THE CHLORINE CONCENTRATION IN A SYSTEM

Controlling the residual chlorine is an integral part of the treatment. Follow the guidelines below in order to ensure that the correct dosage is applied.

1. Chlorine concentration at the injection point should not exceed 30 ppm.

2. The chlorine concentration must be checked regularly at least once or twice a week. When the continuous injection method is used, the injected quantity must be adjusted initially according to the residual concentration.

3. The residual concentration of chlorine must be checked at the point furthest from the injection point within the system.

Residual Chlorine = Injected Chlorine – Chlorine Demand in the system

4. Before taking a sample, open the end of the dripperline to allow the water to flow freely for 10 seconds before taking the sample.

5. The chlorine testing kit has two reagents, in order to measure both the free chlorine and the combined chlorine.

- When chlorine is tested in drainage, treated and/or residual water, measure the combined chlorine.
- When a fertilizer with an ammonium base is injected to the system, measure the combined chlorine.

6. If the chlorine concentration in the water is higher than the capacity of the test kit, the sample must be diluted using distilled water only. In order to determine the concentration, multiply the result by the dilution factor.

The residual chlorine measured with the kit is the result of the injected quantity of chlorine less the quantity of chlorine consumed during the treatment due to its action, mainly over the existent organic/biological matter.

NOTE: The residual chlorine must be verified at the most distant point of the system. Open the end of the fourth or fifth lateral from the end and let the water flow for 10 seconds before taking the sample.

NOTE: Measure the chlorine concentration using a "chlorine testing kit".

The following table lists the recommended chlorine concentration levels to be injected and the required residual concentration of chlorine. After injection, measure the residual concentration and adjust the dosage as follows:

- If the residual concentration is too low, increase the injected concentration or extend the injection time.
- If the residual concentration is too high, decrease the injected concentration.

Chlorine Dosage

Injection Method/Purpose	Concentration to be injected	Residual concentration *
Continuous Injection	< 30ppm	0.5 – 1ppm
Selective Injection	< 30ppm	2 – 3ppm

* The measurement must be taken at the point furthest from the injection point.

DETERMINING THE QUANTITY OF CHLORINE TO INJECT

The quantity of chlorine to be injected will depend on the type of chlorine used.

Gaseous Chlorine

When gaseous chlorine is used, the dosage is based on a chlorinator. A chlorinator controls the gas flow. The calculation is simple since the material is pure (100%).

1 g of gaseous chlorine in 1 m^3/h of water = 1 ppm

CALCULATE THE FLOW RATE OF GASEOUS CHLORINE IN THE SYSTEM, AS FOLLOWS:

Chlorine Dosage

Flow rate of the treated system	100 m^3/h
Desired residual Chlorine at the end of the system	1 ppm
"Chlorine demand" in the system	4 ppm
Concentration required at the injection point	5 ppm (1+4)

The flow rate of gaseous chlorine in the system = 5 * 100 = 500 gr/h (grams per hour)

Liquid and Solid Chlorine

Liquid chlorine is much less stable than solid chlorine. Do not store liquid chlorine for long periods.

CALCULATE THE FLOW PER HOUR OF INJECTED CHLORINE SOLUTION, AS FOLLOWS:

Flow rate of the treated system	100 m^3/h
Concentration of injected chlorine solution	10 %
Desired residual Chlorine at the end of the system	1 ppm
"Chlorine demand" in the system	4 ppm
Concentration required at the injection point	5 ppm (1 ppm + 4 ppm)

Formula for calculating of chlorine solution injection:

$$\text{Flow rate of injected chlorine solution in l/h} = \frac{\text{Required chlorine concentration (ppm)} * \text{Flow rate of treated system } (m^3/h)}{\text{Concentration of solution of chlorine by percentage} * 10}$$

The number 10 in the formula is a coefficient that simplifies the conversion of units.

$$\text{Flow rate of the chlorine solution injected into system} = \frac{5 \text{ ppm} * 100 \text{ } m^3/h}{10\% * 10} = 5 \text{ l/h of chlorine solution}$$

NOTE: The recommended injection time is at least 45 minutes.

NOTE: All the recommendations and examples presented here refer to open field crops (fruits, grains, vegetables, etc.). For treatments in protected crops (greenhouses, tunnels, etc.) consult with the Netafim™ Agronomic Department.

GUIDELINES FOR HYDROGEN PEROXIDE TREATMENT IN IRRIGATION SYSTEMS

Advantages of Hydrogen Peroxide (H^2O^2) as an Oxidizing Agent

For more than a decade, the use of hydrogen peroxide for disinfecting and oxidizing the irrigation water has become widespread.

Prior to this, chlorine was used but it was found that after the oxidation and disinfection process, organic chlorides, which produce carcinogenic compounds, such as Trichloromethane, started to appear, and the process also contaminates the environment.

In fact, many countries have passed laws against chlorinating water and this is a growing trend.

Nowadays, hydrogen peroxide is used for cleaning screen, disc and gravel filters. It is also used as an oxidizing agent for fruits and vegetables prior to storage, and for disinfecting public premises.

Hydrogen peroxide is a strong oxidizing agent. It releases oxygen atoms that react quickly, oxidizing organic matters.

The advantages of hydrogen peroxide are: quick reaction speed, environmentally safe, and it does not generate dangerous by-products.

Hydrogen peroxide is environment friendly, does not contaminate the soil, does not harm the aquifer, and indirectly makes more oxygen available for the soil and the plants.

The oxidation reaction is quick, so the hydrogen peroxide is consumed immediately upon contact with the irrigation water, and it is biodegradable. Its speed enables the use of the hydrogen peroxide for quick oxidation and disinfection of the water source and also in close proximity to the filters.

Hydrogen peroxide is also suitable for oxidizing iron and manganese.

Hydrogen peroxide is commonly used in greenhouses, net houses and tunnels, or on substrates, where the irrigation systems traverse only short distances. Additionally, chlorination could cause significant damage to the roots in the substrates.

The required concentration of hydrogen peroxide at the system inlet depends on the water quality (oxidation potential and the reduction and concentration of organic matter in the water). In general, between 1 and 10 cc of hydrogen peroxide (active agent) are required for each cubic meter of water.

Uses of Hydrogen Peroxide

Hydrogen peroxide is a powerful oxidizing agent and is effective for attaining the following:

- Prevent the accumulation of bacterial slime in the sub-main pipes and dripper laterals.
- Clean irrigation systems from accumulated organic deposits and bacterial slime.
- Oxidize micro-elements (such as iron and sulfur) and trace elements (such as manganese), and prevent bacterial propagation.
- Improve the main and secondary filtration under high organic load conditions.
- Disinfect and treat waste water, sewage, irrigation water, drinking water and swimming pools.
- Prevent and eliminate water odors and interference with biological activity.
- Reduce BOD/COD values by oxidizing organic and inorganic polluting materials.

Hydrogen peroxide is one of the most powerful known oxidizers. It always decomposes in an exothermic reaction into water and gaseous oxygen.

$$2\ H_2O_2 \longrightarrow 2\ H_2O + O_2$$

NOTE: Do not use hydrogen peroxide when pipes and/or storage tanks are made of steel, asbestos cement or covered with cement.
Hydrogen peroxide is not effective for preventing or dissolving scale sediments, sand, etc.

SAFETY

WARNING

HYDROGEN PEROXIDE IS TOXIC AND DANGEROUS FOR HUMANS.

BEFORE USING HYDROGEN PEROXIDE, READ ALL THE INSTRUCTIONS FOR HYDROGEN PEROXIDE TREATMENTS, THE LOCAL LEGAL REGULATIONS AND THE MANUFACTURER'S INSTRUCTIONS.

- Before filling any tank with hydrogen peroxide solution, flush thoroughly to remove any traces of fertilizers.
- Avoid contact with the eyes. The contact of hydrogen peroxide with the eyes may cause blindness.
- Avoid contact with the skin. The contact of hydrogen peroxide with the skin may cause burns.
- Use protective clothing when working with hydrogen peroxide. Use goggles, gloves, mask, long pants, long-sleeved shirts, and high closed shoes.
- Avoid swallowing and inhaling. Swallowing hydrogen peroxide or inhaling its vapors could be fatal.
- During treatment, a second operator must be present who could, if necessary, provide first aid.
- Remain on site during the entire duration of the treatment. Keep all unauthorized personnel outside the treatment area.

NOTE: Direct contact between hydrogen peroxide and fertilizers or other chemical products could create a thermal reaction which could cause the tank to explode. This is highly dangerous.

NOTE: The injection of hydrogen peroxide into irrigation water containing fertilizers is not dangerous.

Physical and Chemical Properties of Hydrogen Peroxide

	Concentration			
	35%	50%	60%	70%
Physical State	Liquid	Liquid	Liquid	Liquid
Color	Colorless	Colorless	Colorless	Colorless
Characteristic Odor	Yes	Yes	Yes	Yes
Molecular Weight H_2O_2	34.01	34.01	34.01	34.01
Boiling Point	108°C	114 °C		125°C
Freezing Point	-32°C	-51°C		-37°C
Vapor Pressure at 25°C	23 mm Hg.	18 mm Hg		11 mm Hg.
Specific Gravity (H_2O=1)	1.132	1.195	1.240	1.288
pH	<5	<4		<2

NOTE: Due to reasons of cost and safety, Netafim™ recommends using a concentration of no more than 50% hydrogen peroxide.

TERMINOLOGY

Injected Hydrogen peroxide is the concentration (ppm) of the product, calculated at the injection point.

Residual Hydrogen peroxide is the concentration (ppm) of the product measured at the furthest treatment point.

Hydrogen peroxide requirements are high for waste water and industrial residual water, and low for potable water and other types of water with no organic load.

For waste waters or industrial residue conditions, it is not possible to calculate the required concentration of hydrogen peroxide, and therefore it is necessary to inject an arbitrary quantity, use the test kit to verify the residual concentration at the end of the system, and correct the dosage accordingly.

For drinking water supply or conditions due to other types of water without biological load, it is easy to calculate the quantity of hydrogen peroxide to be injected into the system.

APPLICATION METHODS

There are two methods for applying hydrogen peroxide:

1. Continuous injection with low dosage

Hydrogen peroxide is injected continuously during the entire irrigation cycle. This is the most efficient method, but the consumption of hydrogen peroxide is the highest.

2. Selective injection

Hydrogen peroxide is injected during the last hour of irrigation. Do not forget to take into account the time required by the hydrogen peroxide to reach the end of the system (see Advancement Time in page 21). With this method, both the consumption and the efficiency are lower than with continuous low dosage injection of hydrogen peroxide.

The frequency of this selective treatment will be determined according to the water quality in the system, and could be daily, weekly, monthly, etc.

NOTE: The residual hydrogen peroxide should be verified at the most distant point of the system. Open the end of the third, fourth or fifth lateral from the end of the system, and let the water flow for 10 seconds before taking samples.

DETERMINATING THE INJECTION POINT

The hydrogen peroxide may be injected into a system at two different points. Each point has advantages and disadvantages.

Hydrogen peroxide – Injection point

Injection Point Location	Remarks
As close as possible to the main pump of the water source (river, dam, well)	Prevents the growth of bacterial slime in the main pipe and protects the irrigation system better than when the injection point is far from the source of water.
Far from the main pump and as close as possible to the treated field	Does not protect the main pipe and is not recommended in cases of effluent water, sulfur, iron and/or manganese

DOSAGE

The required quantity of hydrogen peroxide depends on the water quality, and on the cleanliness of the pipes and the drip laterals, and also on the size of the system.

NOTE: Measure the hydrogen peroxide concentration using a "hydrogen peroxide test kit".

After injection, measure the residual concentration and adjust the dosage as follows:
If the residual concentration is too low, increase the injected concentration.
If the residual concentration is too high, reduce the injected concentration.

Recommended levels of hydrogen peroxide concentration before and after injection

Dosage of Hydrogen peroxide

Injection Method / Purpose	Injected Concentration	Residual Concentration*
Continuous Injection	50 ppm	0.5 ppm
Selective Injection	50 to 100 ppm	2 to 3 ppm
Annual maintenance treatment of the irrigation system	200 to 500 ppm	8 to 10 ppm

*Measurements must be taken at the point furthest from the injection point.

MEASURING THE HYDROGEN PEROXIDE CONCENTRATION IN A SYSTEM

Controlling the quantity of residual hydrogen peroxide is an integral part of the treatment. Follow the guidelines below in order to ensure that the correct dosage is being used.

1. When using the continuous injection method, the hydrogen peroxide concentration must be examined at least once or twice a week regularly. In addition, the injected quantity must be adjusted according to the residual concentration.

2. The concentration of hydrogen peroxide at the injection point should not be more than 500 ppm.

3. The residual concentration of hydrogen peroxide must be checked at the most distant point of the system.

4. Before taking a sample, open the final end of the dripperline, to allow the water to flow freely for 10-15 seconds before taking the sample.

5. The hydrogen peroxide kit includes reagents used for measuring hydrogen peroxide concentrations.

6. If the hydrogen peroxide concentration in the water is higher than the test kit capacity, the sample must be diluted with distilled water. In order to determine the concentration, multiply the result by the dilution factor.

DETERMINING THE QUANTITY OF HYDROGEN PEROXIDE TO INJECT INTO THE SYSTEM

The following examples show how to calculate the initial dosage for various concentrations of hydrogen peroxide. After injection, it may be necessary to adjust the quantity for future injections based upon the residual concentrations, where:

V = Volume (cc) of hydrogen peroxide to be added to the irrigation water during 45 minutes.
C = Desired concentration of hydrogen peroxide in the water (ppm).
Q = Flow rate of the treated system per hour (m^3/h).

- In order to calculate the required hydrogen peroxide volume (35%) to be injected into the irrigation water during 45 minutes, use the following formula: V (cc) = 2.5 x C (ppm) x Q (m^3/h)
- In order to calculate the required hydrogen peroxide volume (50%) to be injected into the irrigation water during 45 minutes, use the following formula: V (cc) = 1.8 x C (ppm) x Q (m^3/h)

EXAMPLE:

Calculate the volume of hydrogen peroxide required (50%) to be injected into the irrigation water using the following data:
Q = 100 m^3/h
The required hydrogen peroxide concentration in the water and the system = 29 ppm
The residual concentration of hydrogen peroxide is = 1 ppm
C = 29 + 1 = 30 ppm
V (cc) = 1.8 x C (ppm) x Q (m^3/h)
= 1.8 * 30 * 100 = 5400 cc
= 5.4 liters of hydrogen peroxide (50%), to be injected during 45 minutes into a system with a flow rate of 100 m^3/h

NOTE: The recommended time of injection is minimum 45 minutes and maximum one hour.

FERTIGATION – TECHNICAL ASPECTS

The fertilizer used must be completely soluble and free of impurities.

Use acid fertilizers in the case of hard water, alkaline water or where pH higher than 7.

Use only iron chelates.

When iron is injected to the system, use only high quality (stable) iron chelates.

NOTE: Do not inject ionic iron in the drip system (iron sulfate, iron chloride). Ionic iron will damage the system. Use iron chelates always.

Phosphoric fertilizers can cause the formation of phosphoric salts, for example with Calcium, Magnesium, etc., increasing the potential of emitters clogging.

Use only phosphoric fertilizers based on orthophosphates. Do not use phosphoric fertilizers based on polyphosphates.

Do not end irrigation and fertilizer injection at the same time. Turn off the fertilizer injection pump before the end of the irrigation, to flush the system of residue from the injected products. Consult the Advancement Time table, page 21, with respect to the minimum time recommended for stopping the injection pump before the end of the irrigation cycle.

ORGANIC NUTRIENTS

The application of organic nutrients through the drip irrigation system requires special attention.

- Organic nutrient solutions are usually less soluble in water and frequently contain high concentrations of suspended solids, which may cause sedimentation, with consequent damage to the irrigation system.
- The application of combinations of organic nutrients shall be avoided, and the preparation of adequate solution must be ensured.
- Effective filtration and system maintenance are prerequisites for the success of the crop.
- System flushing and disinfection treatments are essential when organic nutrients are used, to ensure the system's longevity.

ORGANIC NUTRIENTS

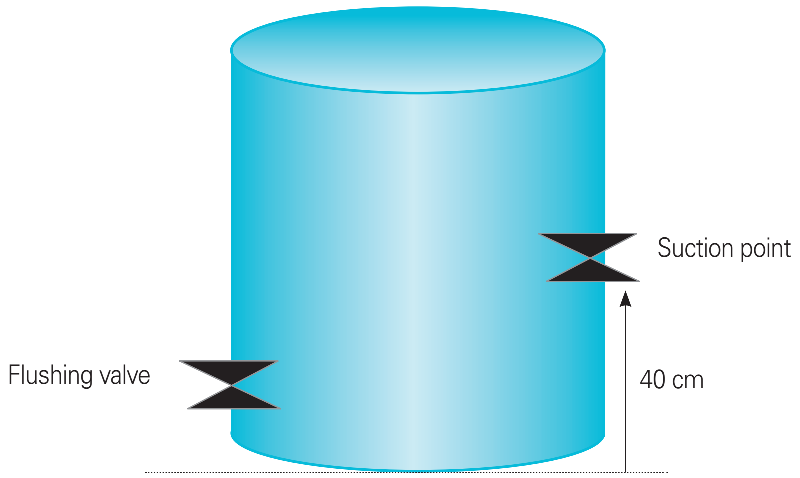
The following is a partial list of permitted organic nutrients that are commonly applied through the irrigation system.

- Guano (marine bird manure) and Urine Slurry.
- Amino acids (from the epithelial enzymatic hydrolysis of the cattle).
- Humic Acids.

PROPER NUTRIENT SOLUTION PREPARATION

Solid organic nutrients must be dissolved in water in adequate concentrations, for example:

- Guano (marine bird manure). Mix with water in a ratio of 1:10. 100 liters of guano per 1000 liters of water.
- The solution should stand sufficient time (7-10 days depending on the season and on the quality of the product) until a solution free of suspended solids is obtained.
- The tank suction point must be located horizontally, at no less than 40cm from the bottom of the tank in order to prevent the suction of the sediments.
- The solids remaining in the tank may be used for spreading on the field.



Organic nutrients should never be applied in combination with inorganic fertilizers.

EXAMPLE:

If humic acids applied as nutrients in agriculture, are combined with an inorganic nutrient, this will cause flocculation.
HUMIC ACIDS + N or K or Ca = FLOCCULATION => CLOGGING!

Another problematic interaction frequently occurs between materials injected into the system and microorganisms living inside the system or that are injected into it. Organic nutrients injected into a system contaminated with bacteria are likely to develop "bacterial slime", which may cause dripper clogging.

NOTE: Avoid mixing organic nutrients in the fertilizer tank.

Organic nutrients must be filtered before they are injected in the irrigation system.
The injection point of an organic nutrient must be located before the main filtration system in order to prevent dripper clogging.

ACID TREATMENT

The following acids are permitted for use in Organic Agriculture:

- Acetic
- Citric
- Oxalic
- Para-acetic

SUMMARY

The use of organic nutrients in drip irrigation systems is possible, but requires special attention. Organic nutrient solutions usually are less soluble in water, and they frequently contain high concentrations of suspended solids, which may cause sedimentation, and consequent damage to the irrigation system.

The application of organic nutrient combinations must be avoided, to ensure that the solution is properly prepared. Effective filtration and system maintenance are prerequisites for crop success. System flushing, acidification and disinfection treatments ensure the proper functioning of the equipment.
It is possible to use chlorine, hydrogen peroxide, etc., for disinfection / oxidation, depending on local standards.

In organic agriculture, processes must be performed according to the pertinent regulations in each country and according to the certifying companies.

GUIDE TO ROOT INTRUSION PREVENTION IN SDI* SYSTEMS

*SDI = Subsurface Drip Irrigation

Plant roots can penetrate the drippers, causing a reduction in the flow rate and possibly an obstruction. This is known as root intrusion.

One of the main causes of root intrusion is insufficient irrigation. This occurs when the plant's water consumption exceeds irrigation. Under these conditions, the roots tend to develop near the emitter and eventually penetrate it.

If this is the cause of the root intrusion, proper irrigation planning may help to minimize root intrusion by equaling the irrigation to the plant's water requirements.

Maintaining proper humidity in the surroundings by means of adequate irrigation planning allows the roots to spread and use the entire available moistened soil volume, instead of concentrating around the emitter. Use of continuous soil humidity monitoring allows better control over the moistening pattern, thus maintaining optimal soil humidity within the dripper's surroundings.

If a crop requires a stress period, it is possible to implement:

a) Herbicide injection in the exact dosage to prevent rootlet ends from growing near the dripper, without damaging the plant itself.

b) For surface systems with root penetration potential, especially those where the irrigation line is covered by leaves, plastic items, foliage, etc., Netafim™ recommends manually moving the dripperlines to physically separate the irrigation line and the roots.

NOTE: Check all relevant local (state) regulations before deciding which herbicide to use.

Root intrusion

Root intrusion occurrence is probable in times of water-induced stress.

Such stress may be:

- Planned at the farmer's discretion.
- Caused by a lack of water or a faulty water supply.
- Due to an unforeseen increase in water consumption by the crop.

If a scheduled stress is necessary, the chemical treatment should be executed prior to the start of such stress.

Herbicides and Dosage

The following are examples of commercial products used for the prevention of root penetration.

- Treflan (active substance: Trifluralin 48%)
- Stomp (active substance: Pendimethalin 33%)
- Alligator (active substance: Pendimethalin 40%)
- Prowl (active substance: Pendimethalin 40%)

The percentage of active substance depends on the manufacturer.

To calculate the amount of commercial product to be injected through the drip system, proceed as follows:
a) Use the coefficient of 6 (six) and divide by the percentage of active substance in the commercial product.
b) The result of this calculation is the volume in cubic centimeters (cc) of the commercial product to be injected per dripper.
c) Multiply the number of drippers per surface unit to be treated by the volume of the commercial product calculated above (b).

6 / % active substance in the commercial product = cc product/dripper.
The number 6 is a coefficient that simplifies unit conversion.

EXAMPLES OF COMMERCIAL PRODUCTS:

Treflan: 6/48 = 0.125 cc/dripper.
Therefore, 1 liter of Treflan is enough for 8,000 drippers.

Stomp 330: 6/33 = 0.182 cc/dripper.
Therefore, 1 liter of Stomp 330 is enough for 5,945 drippers.

Alligator 400: 6/400 = 0.150 cc/dripper.
Therefore, 1.5 liters of Alligator 400 are enough for 10,000 drippers.

Prowl 400: 6/400 = 0.150 cc/dripper.
Therefore, 1.5 liters of Prowl 400 are enough for 10,000 drippers

Note: In cases where the number of drippers per lineal meter of irrigation line exceeds 3, the number of drippers calculated will be according to this quantity (3 drippers per meter) and not according to the actual quantity of drippers.

EXAMPLE 1:

One hectare with 6,500 meters of irrigation lines with dripper spacing 0.20 meters apart:
6,500 meters divided by 0.20 meters equals 32,500 drippers per hectare (actual quantity).

Based on the above, as this case has 5 drippers per lineal meter of irrigation line, i.e. more than 3 drippers/meter1, the calculation will be made according to 3 drippers per lineal meter of irrigation line.

Thus, 6,500 meters multiplied by 3 drippers equals 19,500 drippers per hectare (quantity calculated for application).

The dose to be injected will be 19,500 drippers multiplied by the volume in cubic centimeters (cc) per dripper of the commercial product calculated above depending on the active ingredient of the said product.

Determining the quantity and frequency of treatments

The number of treatments per season with one of the above-mentioned herbicides should be between 1 and 2, depending on the type of soil, accidental or induced irrigation interruptions, and duration of the irrigation and the fertilization seasons.

In perennial fruit trees, the recommendation is for up to two treatments per season, starting from the second year of age. The first treatment should be implemented in the first third of the irrigation season. The second treatment should be implemented when beginning to reduce water applications to the crop towards the end of the irrigation season.

In the case of new plantations and plantations of up to one year of age, consult with Netafim's Agronomy Department.

In open field crops (seasonal or perennial), treatment should be obligatorily implemented once a year. The time for this mandatory treatment is when beginning to reduce water applications to the crop towards the end of the irrigation season.

Certain crops will require one additional treatment during the irrigation season, because previously induced interruptions or reductions of water volume that were carried out increase the potential for root penetration into drippers.

In the case of sandy soils (more than 70% sand and less than 8% clay), regardless of the type of crop, it is recommended to execute the herbicide treatment, separating the application into two injections, each of which should be half of the dose calculated for a single application. The interval between these two injections will be two (2) weeks.

For any query, please contact the Agronomy Department at Netafim™

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When Not to Use Herbicides to Prevent Root Intrusion

The treatment is contraindicated under the following conditions:

a) When the soil is saturated (due to rain or irrigation)

b) Near the time of crop planting or sowing and/or when the volume of the roots is very small

c) In soilless substrates

d) When the relevant authorities prohibit the specific treatment

Before Treatment

Perform the following tests a few days before the scheduled treatment:

- Turn the water on for 20 minutes. If puddles appear, the soil is too wet and not suitable for treatment.
- Check the irrigation lines for leaks and bursts. Repair all defects before the treatment.
- In grass, verify that the irrigation lines are properly buried and are not located between the surface of the soil and the grass carpet.
- Verify that the pump and the central control are in proper working condition.

NOTE: The soil must not be too wet during treatment. If the soil is too wet, Netafim™ recommends partially drying the soil by postponing an irrigation cycle before the treatment.

Any type of fertilizer injection pump can be used to apply these products.

EXAMPLE:

Calculate the minimum amount of Stomp 550 plus water required for an injection lasting 20 minutes in accordance with the pump's specifications:

Stomp 550 required per dripper	6/55 = 0.11 cc
Total number of drippers in the system to be treated	10,000 units
Total required amount of Stomp	10,000 x 0.11 cc = 1,090 cc = 1.09 liters
Injection pump flow rate	240 l/hour

20 minutes = 60/3

240 l/h / 3 = 80 liters

This pump can supply 80 liters in 20 minutes.

These 80 liters are composed of 78.91 liters of water plus 1.09 liters of Stomp 550.

Treatment procedure

Turn the water on and let it flow until pressure stabilizes.

Fill a clean tank with a volume of water equal to the volume required for an injection lasting 20 minutes (78.91 liters in the example above).

Immediately add the herbicide to the water in the tank.

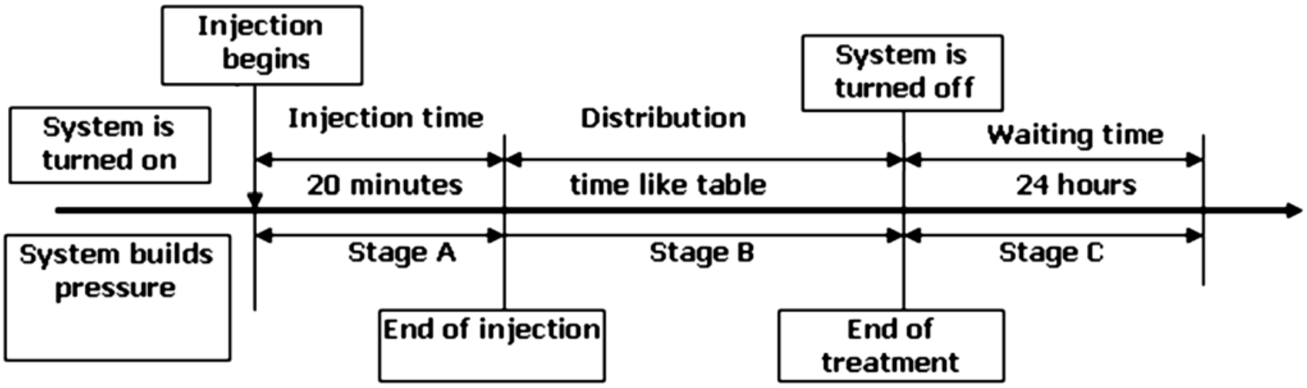
Inject the treatment from the tank into the system. If the solution was calculated correctly, the injection will end in 20 minutes.

Before turning off the system, allow the water to continue flowing through it during the required period of time (see AdvanceTime, page 20).

NOTE: Leave the system irrigating after herbicide injection is completed.
Observe the advance time (page 20).
Do not delay or move up the system's shut down.
After treatment, wait at least 24 hours before the next irrigation cycle.

Treatment Summary

Fill the system until pressure is stable.
Stage A: Inject the solution for 20 minutes.
Stage B: Solution is distributed through the system; allow water to continue flowing as per the Advance Timetables.
Stage C: Turn off the water. Do not delay water turn-off.
Wait 24 hours before the next irrigation cycle.



INTENSIVE ANTI-DRAINAGE (CNL) IRRIGATION SYSTEMS

Anti-Drainage Systems (CNL) – Introduction

The Netafim™ anti-drainage (CNL) dripper was developed specifically for frequent pulse and uniform irrigation.

For attaining uniform irrigation, it is necessary to ascertain that all the drippers open and close simultaneously and that the water in the laterals was not drained. CNL drippers prevent water from draining from the higher points of the system towards the lower points (provided the difference in heights does not exceed the allowed limits).

Water quality maintenance requirements for CNL systems are stricter than for standard systems. Therefore, the use of CNL systems is recommended only when pulse irrigation results are really necessary.

Anti-Draining System Requirements

- All the system components and accessories (for example, connectors and valves) must be manufactured according to system specifications and anti-drainage requirements.
- The response time of the valve must be short compared with the length of the irrigation pulse. Otherwise, the short irrigation pulses will be too short for any valve.
- The system must be capable of supplying all the crop's water requirements during peak consumption.

Water quality refers to the concentration of chemical substances dissolved and suspended in the water, as well as the physical and biological properties of the water.

Maintenance

Preventive maintenance is, in the time axis, the most effective, most economical and the most profitable. If maintenance is carried out from the time of installation, the system will function optimally.

Preventive maintenance prevents physical, chemical and biological obstruction of the system. Some operations are carried out at the water source, and some at the irrigation system's head control.

If the system remains full of water for a long time, the water temperature might increase. This generates a biological film and sediments (insoluble minerals) which accumulate quickly.

Following is a list of the most common preventive treatments:

- Effective flushing of the entire system
- Oxidation and disinfection treatments – for example, with chlorine, hydrogen peroxide, air or ozone
- Acidification treatments

Useful hints for system maintenance

It is important to take the following into account:

- Continuous chlorine injection for oxidation and disinfection is permitted only when the injected solution concentration is lower than 1 ppm, and provided the pH level is above 5.5.
- Hydrogen peroxide for oxidation and disinfection at the required frequency, both for continuous and localized injection. See the guide of the Advantages of the Hydrogen peroxide (H^2O^2) as an oxidation agent.
- Do not allow the pH level to drop below pH 3 for more than one hour. This is particularly important when chemical agents, disinfectants, oxidants or nutrients are present in the system.
- Do not inject disinfectants, pesticides, herbicides or oxidants together with the nutrients. If it is necessary, stop the injection of the nutrients, flush the system with water until no residual nutrients remain, and only then proceed with the maintenance tasks.

- If nutrients are injected more than twice a week, Netafim™ recommends flushing the system with water after Nutrigation™, to eliminate the remaining nutrients. If nutrients are injected at a higher frequency, flush the system at the end of each day. Otherwise, flush the system at least once a week.
- After injecting products against weeds, roots and/or organic nutrients, perform an extended irrigation only with water until the system is free of them.
- Flush the irrigation system thoroughly to remove any sediment from injected substances that accumulated at the ends of the laterals. This must be done immediately after each injection of chemical substances into the system.

Problems Resulting from Injecting Incorrect Substances

- Accumulation of sediment deposits in the drippers as the result of reactions between the nutrients and the water.
- Physical and chemical damage to the irrigation equipment.
- In case of doubts regarding what kind of nutrients, disinfectants, pesticides, etc., should be used, consult with the experts at Netafim™ before application, and/or send a sample of these substances to Netafim™ for preliminary testing.

GENERAL CONVERSION TABLES

DISTANCE

1	Kilometer	=	1.094	Yardas
1	Kilometer	=	0.621	Mile
1	Meter	=	3.281	Feet
1	Meter	=	39.370	Inches
1	Meter	=	1.094	Yardas
1	Centimeter	=	0.039	Inche
1	Foot	=	0.305	Meter
1	Inch	=	0.025	Meter
1	Inch	=	2.54	Centimeters
1	Yard	=	0.914	Meter
1	Mile	=	1.609	Kilometers
1	Mile	=	1609.344	Meters

AREA

1	Hectare	=	0.4047	Acre
1	Acre	=	2.470	Hectare
1	Hectare	=	10000	m^2
1	Acre	=	4.047	m^2
1	Hectare	=	0.004	millas^2
1	Centimeter^2	=	0.155	pulgada^2
1	Meter^2	=	1.196	yarda^2
1	Kilometer^2	=	0.385	Mile^2
1	Inch^2	=	6.452	Centimeter^2
1	Foot^2	=	0.092	Meter^2
1	Yard^2	=	0.836	Meter^2
1	Mile^2	=	2.59	Kilometer^2

FLOW

1	Meter^3/h	=	264.1721	Gallons/h
1	liter/h	=	0.2641721	Gallons/h

PRESSURE

1	Bar	=	14.69595	PSI
1	PSI	=	0.06894757	Bar
1	Bar	=	100	Kilopascal
1	PSI	=	6.894757	Kilopascal

POWER

1	kilowatt	=	1.341022	HP
1	kilowatt	=	56.91965	BTU/minute
1	HP	=	0.7456999	kilowatts

WEIGHT

1	grams	=	0.0353	Ounces
1	kilograms	=	2.205	pounds
1	Ounces	=	28.35	grams
1	Ounces	=	0.0283	kilograms
1	pound	=	0.454	kilograms

TEMPERATURE

0°	Celsius	=	32°	Fahrenheit
5°	Celsius	=	41°	Fahrenheit
10°	Celsius	=	50°	Fahrenheit
15°	Celsius	=	59°	Fahrenheit
20°	Celsius	=	69°	Fahrenheit
25°	Celsius	=	77°	Fahrenheit
30°	Celsius	=	86°	Fahrenheit
35°	Celsius	=	95°	Fahrenheit

VOLUME

1	gallon	=	4.546	liter
1	liter	=	0.22	gallon
1	Pinta	=	0.546	liter

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